Quarterly Progress Report

Division 7

Engineering

15 January 1963

Lincoln Laboratory

MASSACHUSETTS INSTITUTE OF TECHNOLOGY

Lexington, Massachusetts

294 972

Unclassified

The work reported in this document was performed at Lincoln Laboratory, a center for research operated by Massachusetts Institute of Technology, with the joint support of the U.S. Army, Navy and Air Force under Air Force Contract AF 19(628)-500.

Quarterly Progress Report

Division 7

Engineering

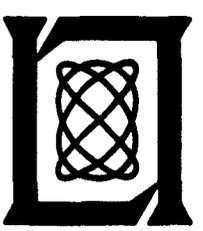
15 January 1963

Issued 21 January 1963

Lincoln Laboratory

MASSACHUSETTS INSTITUTE OF TECHNOLOGY

Lexington, Massachusetts



INTRODUCTION

The Engineering Division provides general engineering support to the entire Laboratory, including mechanical, construction,and control systems engineering. In addition, the Division provides centralized shop and physical plant services. This report, covering the quarterly period from 1 October to 31 December 1962, presents a summary of only the principal engineering activities, such as the upgrading of the Millstone Hill radar facility to L-band, fabrication and installation of the new research facilities at Haystack Hill, design of optical equipment for installation in a KC-135 aircraft as part of the PRESS program and development of dispensing equipment for the West Ford program.

15 January 1963

J. F. Hutzenlaub
Division Head

TABLE OF CONTENTS

ORGANIZATION LIST

DIVISION OFFICE

David D. Jacobus, *Division Head*
John F. Hutzenlaub, *Associate Head*
Arthur T. Newell, *Assistant Head*
Leslie C. Blomberg, *Assistant*
Arthur E. Johnson, *Assistant*
Paul L. E. Alberti
Robert V. Meyer

GROUP 71 – MECHANICAL ENGINEERING

Edgar W. Blaisdell, *Leader*
Fausto G. DeSantis, *Assistant Leader*
Howard A. MacDonald, *Assistant Leader*

L. A. Baghdoyan
M. W. Brawn
E. Chateauneuf
E. A. Davidson
B. A. Dudley
W. R. Fanning
L. P. Farnsworth
F. A. Folino
S. L. Hensel, Jr.
A. Howitt
E. Jozefowicz
P. G. Knowles
A. R. Leyenaar
R. A. Muldoon
J. F. Orabona
C. A. Pappas
C. A. Peterson, Jr.
D. A. Regillo
A. M. Rich
A. M. Sanderson
C. Sullivan
E. C. Warren

GROUP 75 – CONSTRUCTION ENGINEERING

David C. Moore, *Leader*
John B. Paddleford, *Assistant Leader*

S. B. Barnard
M. I. Brown
E. L. Clarke
E. P. Gaudette
R. D. Mooney
P. Stetson
R. J. Sutherland
M. Williamson

GROUP 76 – CONTROL SYSTEMS

Stobo H. Wright, *Leader*
Alfred O. Kuhnel, *Assistant Leader*

F. L. Bacchialoni
W. C. Erwin
D. A. Mudgett
E. D. Ralowicz
D. G. Stuart
S. E. Woodbury

MECHANICAL ENGINEERING
GROUP 71

I. GENERAL RESEARCH

A. Special High-Pressure Apparatus for Materials Research

1. Tetrahedral Apparatus

In this past quarter, more than 70 experiments were made with the L5-15 multipiston device, including basic calibration runs on bismuth, thalium and barium.

Pressures of 70 kilobars now can be easily reached without anvil failure. Since it was impossible with the original anvil design to reach the barium transition pressure of 60 kilobars without fracturing one or more parts in the toolstack assembly, it is felt that the modified anvils are performing better than expected. It has been suggested that the hydraulic system of the apparatus needs to be improved, and a better way to control the traveling rate of the four pistons should be considered.

2. The L7-25 Internal Anvil Device

Because of the success that has been obtained with the L5-15 high-pressure apparatus it was thought desirable to develop a model having greater volume capacity. Again a device consisting of circumferentially supported conical pistons which compress a sample retained in a strongly reinforced cylinder has been designed and proposed to manufacturers. With this new apparatus it will be possible to work with specimen volumes of 0.5-inch diameter by 1.25-inch length as opposed to a 0.25-inch diameter by 0.6-inch length for the L5-15.

B. Haystack Antenna System

1. Optical Measuring Equipment for Reflector

Fabrication of the double turret line-of-sight Keuffel and Esser System is nearly completed. Inspection of the individual penta mirrors is scheduled for early January 1963, and the acceptance test for the entire turret head, a few weeks later.

Arrangements are being made to ship the North American Aviation, Inc., turret head to Keuffel and Esser during the period between the disassembly of the antenna at NAA and the erection of the antenna at Haystack Hill. This will permit the NAA turret to be modified to accept the second turret.

2. RF Box (Radar)

An RF Box has been received and set up within the Laboratory for installation of receiver system components. In addition, it will be outfitted for radiometric experiments for field and antenna evaluation.

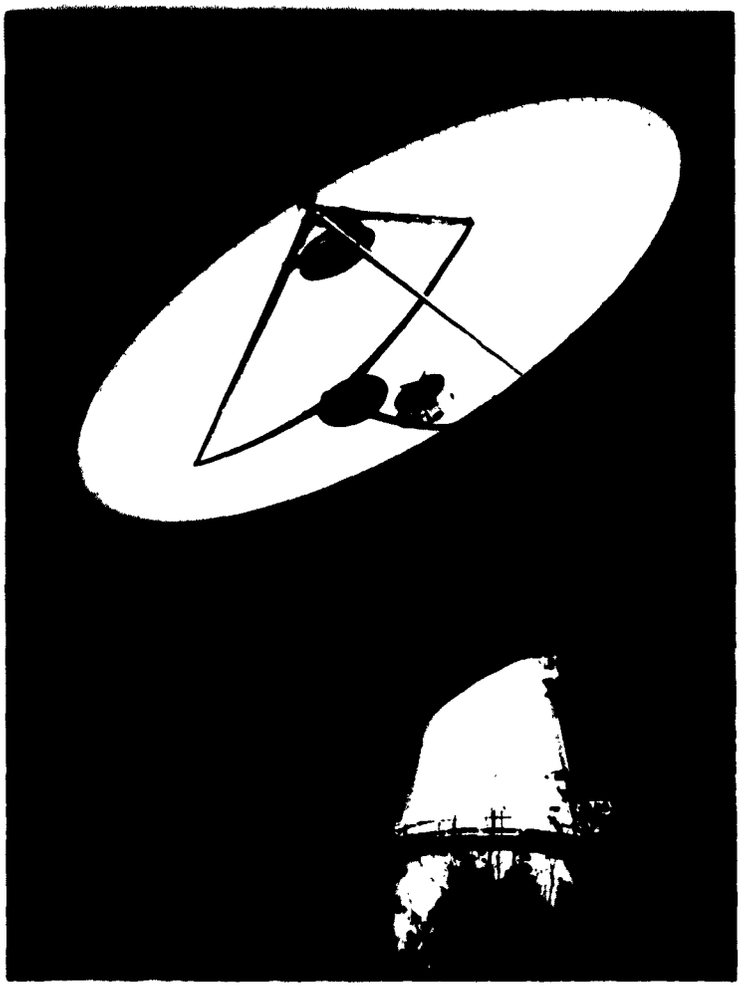


Fig. 71-1. L-Band conversion of the Millstone Hill radar system.

Models:– A model of a four-horn, four-klystron transmitter system was completed and mounted in the RF Box. This model included only the waveguide plumbing associated with the sum and difference circuits. However, during this report period it was tentatively decided to use a single-klystron transmitter and circular polarization. This decision eliminates the need for rotary joints. A new waveguide model of this system is now being built.

Components:– The proposed change in design, as mentioned above, has incorporated additional RF components, such as polarizers. Experimental hardware for these components is being designed and built for testing.

Cooling:– A test setup has been used extensively during this period to ascertain the cooling and power-handling capabilities of the RF plumbing. Numerous pieces of hardware were designed and built for this setup.

3. Maser

All the components for laboratory evaluation of the maser configurations have been supplied to the Microwave Components Group (Group 46). These components have been fabricated utilizing electroplating techniques developed by the machine shop.

Cooling of the maser in the Haystack system is to be accomplished by a closed-cycle helium refrigerator which is being evaluated in the Laboratory. An early model of a closed-cycle refrigerator is currently undergoing tests. This system uses a three-gas cascade system capable of attaining 4.2°K with 0.75 watt of refrigeration.

II. SPACE SURVEILLANCE TECHNIQUES (SST)

A. L-Band Conversion of the Millstone Hill Radar System

1. Site Reassembley and Antenna Erection

Site reassembly and erection of the antenna system was started on 2 October 1962 and completed with interim RF components on 15 November 1962. Approximately 90 percent of the final RF system was installed, including the interim feed-horn assembly. This temporary arrangement of RF equipment permitted operation of the system to conduct the Venus experiments starting in mid-November 1962. Figure 71-1 shows the temporary system in operation.

During the course of assembly, a planned program of inspection, tests and measurements was carefully carried out. The data from all phases of this program, with a detailed analysis, are in the project file.

2. Monopulse Feed Assembly

Construction of the 12-horn monopulse L-band waveguide feed assembly is nearing completion (see Fig. 71-2). An extensive test program is expected to start early in the first quarter of 1963 at the Lincoln Laboratory Antenna Test Range, Bedford, Massachusetts. Installation in the L-band Millstone system is expected to take place midway through the first quarter of 1963.

The new slip-ring assembly, now under construction, will be installed in the L-band Millstone system at the time of the new feed-horn installation.

Fig. 71-2. Shop assembly of the 12-horn monopulse feed assembly.

B. Test and Analysis Program

The Division 7 Quarterly Progress Report, 15 October 1962,* describes the test and analysis program for determining the structural integrity of the system. As a direct result of data from the 125-percent load test on the counterweight truss, an investigation was initiated on the addition of a redundant member that would render the structure safe from cleavage failures. The investigation resulted in the design and installation of a turnbuckle-cable truss assembly. Prior to installation, the truss assembly was instrumented with strain gages and proof-tested at M.I.T.

During installation, the truss was preloaded to 50,000 pounds. Preloading had the effect of maintaining truss strain levels with nominal stresses well below the 4200-psi tension (upper chords) and 13,000-psi compression (lower chords) that resulted from the previous 100-percent load test on the counterweight truss (without the cable-truss reinforcement). Static and dynamic testing of the system revealed very small increased stresses in the counterweight truss members of 1000 psi in tension and less than 1500 psi in compression.

The testing program included static and dynamic testing on the 10-foot-diameter secondary reflector and its tripod support at the contractor's plant. Static tests measured stresses at connection points, structural members and welds. Dynamic tests were made to determine resonant frequencies of the secondary reflector and spars of the tripod at various excitation levels.

Following completion of the system assembly, the remainder of the test program was implemented. The program included static and dynamic tests and measurements on the turret support structure, RF equipment shelter, "Brooklyn Bridges," secondary reflector with tripod support, primary reflector, elevation static imbalance, azimuth static imbalance, operating torque both in elevation and azimuth and the previously discussed truss assembly.

Data from the above tests and measurements were evaluated as soon as they became available to determine conformance to specified requirements and design computations. The data from all phases of the program, with a detailed analysis, will be embodied in a report to be published early in the first quarter of 1963.

Measurements yet to be made will determine the geometric relationship between the secondary and primary reflectors in all attitudes of the Cassegrainian antenna system in elevation. Unique instrumentation is being readied for measurements to be made in the first quarter of 1963.

C. IF Rotary Joints

Assembly and test of the five rotary joints have been completed. They have been delivered to the Millstone Hill radar site.

D. L-Band TR Unit

Fabrication of the new cavity section for the L-band gas tube TR unit has been completed. It is currently being oven-braze assembled. The fabrication of a second aluminum alloy backup unit is approximately 50 percent completed.

* Division 7 Quarterly Progress Report [U], Lincoln Laboratory, M.I.T. (15 October 1962), ASTIA 287558.

III. PROJECT WEST FORD

A. UHF L-Band Dipole Dispenser

The dispenser, which is designed to eject dipoles 0.001 inch in diameter and 0.0075 inch in diameter, in addition to a 10-inch inflatable Mylar balloon is now undergoing testing. The first of the tests was conducted in air, but additional testing in a vacuum will be conducted to ascertain the ejection and spin velocities of the dipoles under simulated operating conditions.

B. X-Band Dipole Dispenser, Mark II

Parts for the redesigned pin-puller release mechanism have been fabricated, tested and are performing satisfactorily. Environmental mechanical tests on this unit are nearing completion. The results of these tests indicate satisfactory performance.

C. X-Band Dipole Dispenser, Mark III

Design of the ejection mechanism for the dipole dispenser has been completed and fabrication started. The mechanism will be tested by using a simulated dipole package.

D. Research on Satellite Structures and Materials

Research on the structural design of satellites is currently being conducted. Various design concepts and material evaluations are being considered and analyzed to determine which types of structures have the greatest strength- and rigidity-to-weight ratio.

E. X-Band Tracking Feed, Model II

Fabrication of the components of this feed is approximately 50 percent completed. The non-tracking interim feeds have been installed at the Millstone Hill and Camp Parks sites.

A high-power feed-horn radome design has been developed. Fabrication of these radomes is approximately 75 percent completed.

F. Analog Orbit Computer

A "first-cut" design layout of the incremental variable-speed gear box for generating "mean anomaly" has been completed. Some minor redesign is being undertaken to simplify construction and improve component accessibility. Design layouts are in process for adding variable rate inputs of 0.01° per day to 3.5° per day to the nominally static quantities of "range angle of perigee," "inclination" and "right ascension of ascending node."

IV. SYSTEM 461

A. Satellite Tracking Antenna

Design and fabrication of the antenna and pedestal are proceeding on schedule. Most of the major weldments have been fabricated and bids are now being received for machining and assembly of the pedestal components.

The order for the reflector and secondary has been placed with Antenna Systems, Inc., of Manchester, New Hampshire. All the motors and gear reducers for the drive systems have been

received. The slip-ring assembly has been ordered from Gorham Electronics for delivery in February 1963. Hydraulic buffer stops have been ordered from the Buffalo Hydraulic Division of Houdaille Industries for delivery also in February 1963. No delay is anticipated in delivery of these items.

Design progress has been normal, with most major items having been completed. There remain some areas of work such as data gearing, elevation motor mount and slip-ring installation which are now being developed. Installation of the RF feed system is also being engineered.

V. RE-ENTRY PHYSICS

A. S-Band Monopulse Feed

Fabrication of the components for this antenna system is approximately 90 percent completed. Assembly of the antenna for testing purposes at the Millstone Hill site is scheduled to start during the week of 4 February 1963.

B. Trailblazer II Optical Experiment

1. Quartz Window

Fabrication of the quartz window mounting has been completed. The differential expansion problem has been overcome by bonding quartz studs 1/4 inch in diameter to the window. The studs are then held to the invar support ring through an intermediate high-temperature silicone rubber gromet. The window is undergoing mechanical environmental testing and is scheduled for thermal environmental testing in March at the Cornell University Gas Superheater.

2. Cornell Experiment

Design of the optics has been completed. The remainder of the package is undergoing redesign to incorporate a cooling system and is 30 percent completed.

VI. PRESS PROGRAM

A. Ground-Based Optical Calibration Equipment

All of the calibration equipment has been completed and installed in the calibration van. The van was shipped to Hawaii in October 1962.

B. Multi-Element Total Event Spectrometers (METES)

The design of the short-wave spectrograph is nearing completion. Long lead time items are now being procured. The unit should be ready for manufacture by the end of January 1963.

The long-wave spectrograph design is now undergoing computer analysis.

C. Instrument Mounts and KC-135 General Arrangement

Outfitting the KC-135 with its full complement of instrumentation is being accomplished in three phases:

Phase I — All equipment required for Phase I operation has been installed in the aircraft, including the radar beacon, direct writing oscillograph and manual acquisition aid. Aircraft maintenance check flights are now under way.

Phase II The aircraft general arrangement for Phase II has been released to the Airborne Engineering Office of the 3245th Air Base Wing at Hanscom Field for installation design action. A system block diagram and subsystem block diagrams have been completed, and wiring diagrams are in process. Power distribution requirements have been established and a distribution panel is being designed. An array of 19 ruggedized electronic racks has been designed and construction is under way. Final installation design for the two-axis mount cannot be completed until firm information is received for the electronics of the mount.

A mock-up of a major portion of the project space in the airplane is being constructed in the Laboratory. This will permit integration of subsystems in the Laboratory prior to aircraft installation.

Phase III The aircraft general arrangement for Phase III has been released to ARE. Specifications are being prepared for installation of windows in the aircraft. Sufficient firm information has been received for the two color trackers, METES and cinespectrograph,so that we may begin final design of these instrument mounts. Final design information for the orthicon and the long focal length camera is expected from the contractors within 30 days.

VII. BALLISTIC MISSILE RE-ENTRY SYSTEMS (BMRS)

A. Digital Television Spectrometer (DITS)

A digital television spectrometer (DITS) has been designed and fabricated for Group 26. The DITS is to be used in conjunction with a White Sands telescope in a feasibility study for ground optical coverage of the White Sands Missile Range program. Two additional DITS units are being fabricated for experimental purposes in the Laboratory.

In conjunction with the DITS, a modified Schmidt optical package is being designed for Group 26 to be used in the study of the feasibility of using vidicon tubes for radiometric measurements. The DITS, without the spectrometer portion, will be incorporated in the design.

B. Optical Radar

Components for the transmitter of the system are being fabricated in the shop and will be ready for test early in January 1963. The system consists of a mirror 12 inches in diameter having a 13-inch focal point that is supported in a tube 14 inches in diameter which also houses a cooled device designed by the Applied Physics Group (Group 85). This tube is supported in such a way as to allow rotation in two planes. The receiver for the system is currently in the final stages of design.

CONSTRUCTION ENGINEERING
GROUP 75

I. HAYSTACK HILL

Construction of the main building and computer wings is complete. Construction of a pad for a storage building will start early in January; this prefabricated metal building is being relocated from the Sauratown communications site in North Carolina. Design of a guard house is complete, but this construction will be delayed until the weather ameliorates.

II. PROJECT WEST FORD

Construction has started for an extension to Building E in the Lincoln Laboratory complex to house the space simulation chamber to be used to test dipole dispensing systems. This installation will require a liquid nitrogen storage and pumping system. Facilities will be provided to supply the general Laboratory requirements for liquid nitrogen from the same system.

III. PRESS PROGRAM

Design criteria are also being prepared for two separate facilities for Project PRESS. One will involve modification of four quonset huts and a hanger at Hickam Air Force Base, Hawaii, to house the technical and support operations connected with the operation of the PRESS aircraft. This work will be designed by an engineering firm in Honolulu under direction of Group 75 and will be constructed under the direction of the Hickam Base Civil Engineer.

The second facility is an integrated photographic data processing and administrative center to be built adjacent to the computer building and TRADEX on Roi-Namur in the Kwajalein Atoll. This building will be designed and built by the Corps of Engineers, U.S. Army.

CONTROL SYSTEMS
GROUP 76

I. OBJECTIVES

Group 76 is responsible for the design and development of control systems for various Laboratory programs. This equipment consists primarily of automatic controls involving servomechanisms and analog computers. In addition, Group 76 assists other Laboratory groups in the design and development of required electromechanical components.

II. GENERAL RESEARCH

A. 8-mm Lunar Tracker

Manufacture and installation of control equipment to provide the 28-foot antenna system with earth rate drive capability was completed. Tests of closed-loop rate operation were generally satisfactory. However, it proved impossible to attain the designed maximum velocity because of excessive friction in the gear reducers used between motors and load. This problem is being investigated in cooperation with Group 71.

B. Haystack Experimental Facility

Detailed technical monitoring of all phases of the Air Force Haystack contract being carried out at North American Aviation, Inc., Columbus, Ohio has continued. Areas active in this period at NAA were engineering, design, manufacturing, in-plant erection, in-plant test and component delivery to the Haystack site.

Directly supported Laboratory work at NAA outside the U. S. Air Force contract with NAA now consists of a dynamic analysis of the antenna structure and control system in a tracking mode, static experimental test of the primary reflector without and with the honeycomb face panels attached, engineering study and design of the antenna services interconnection system and full-scale model test of the elevation and azimuth cable wrap systems.

1. Engineering and Design

The primary NAA engineering activity consisted of backup to shop activity in primary reflector and pedestal assembly, analysis of reflector panel production measurement data, analysis of hydrostatic bearing test data, analysis of test data on static loading of primary reflector backup structure, formulation of the structural equations of motion for use in the dynamic analysis, study work on design of the cable wrap and design of the wrap test system.

2. Manufacturing and Assembly

All inboard reflector panels have been bonded, with contour measurement completed and approved for reflector installation on 14 of 33 panels. No acceptable outer panels have been bonded to date.

The primary reflector backup structure was completely assembled in-plant and readied for static-load testing. The next operation is to be panel installation.

The antenna pedestal in-plant assembly, alignment, plumbing, wiring and preparation for testing were completed.

3. Test and Measurement

Antenna-pedestal in-plant tests were conducted to determine performance of the azimuth end-of-travel bumper system, the fully loaded hydrostatic bearing, the manual synchro control mode and the pedestal section between bolt-down points and top of the yoke when subjected to vibration. The pedestal was then released for tear-down and packaging.

The hydrostatic bearing tests were of primary significance, with test data showing no difficulty, and performance was in agreement with design predictions. The only significant deviation was an average operating-thrust oil-film thickness of 0.005 inch instead of 0.008 inch. This film thickness is adjustable should a change be desirable. Pedestal operational tests showed general conformance with specifications. Natural frequencies recorded did not show an area for concern, the lowest recorded being 2.05 cps in a line along the elevation axis.

In-plant static load-deflection tests on the primary reflector backup structure were completed. Except for a few isolated cases, early reduction of test data has shown better than 90 percent agreement with predicted deflections along lines parallel to the dish axis lying in planes that divide the dish into four equal 90° quadrants. Initial consideration of the major portion of test data indicates that good agreement can be expected at the high deflection values for deflections in planes parallel to the outer-diameter circle of the reflector.

Direct independent static test checks through measurement of member elongation were carried out by Lincoln Laboratory personnel at various stages of the backup structure assembly. This data, along with the NAA static deflection data above, will be run through our own computer programs for verification analysis.

The digital angle data system under development at Telecomputing Corp., Los Angeles, is undergoing final testing on the electronic quantizing equipment and initial testing on the antenna-driven analog output data disks. Present indication shows a 17-binary-bit accuracy has been achieved. Nineteen-bit accuracy is required.

4. Site-Related Items

The significant activity here has been the approval of the antenna erection procedure proposed by NAA, establishment of initial on-site activity of the antenna erection manager, delivery of the hydrostatic bearing to the site and in-transit status of the remainder of the antenna pedestal and componentry via railroad at the end of this period. Active assembly on site is to start the second week in January 1963.

A full-scale mock-up of the main antenna control consoles has been delivered to the site for location and proportion evaluation. The primary junction boxes for system interconnection have been delivered to the site for installation. The junction area they represent in the control room is approximately 315 square feet in five wall-mounted boxes 7 feet high by 9 feet long.

III. SPACE SURVEILLANCE TECHNIQUES

The entire antenna control system of the Millstone Hill radar was completely rewired to incorporate necessary changes and additions to the previous control system. Tests of the various switching functions and protective circuitry were completed.

Due to the urgency of operational requirements, the servo position loop was closed with no attempt to provide optimum performance. Further effort will be devoted to the positioning system when the antenna is made available. No attempt was made to close the tracking loop pending installation of the tracking feed system.

Measurements of the new 84-foot L-band primary reflector were completed. The greatest deviations in the plane of the wave front caused by errors in the surface of the primary reflector were computed to be ±1/2 inch.

IV. PROJECT WEST FORD

Coordinate converters for antenna-aiming purposes were installed at the Millstone site and at Camp Parks, California. Maximum errors in elevation and deflection did not exceed two minutes of arc for these units.

Investigation into the problem of pointing a proposed three-axis azimuth-cross level-elevation mount with analog command data from the proposed analog orbit computer was undertaken. Power and control components for the three-axis mount were tentatively selected.

V. RE-ENTRY PHYSICS

The problem of installing digital encoders on the 48-inch telescope at the Arbuckle Neck field site has been investigated. Tentative plans call for the installation of optical-type shaft-angle encoders on the azimuth and elevation axes, as well as optical-type linear encoders for measurement of piggy-back servo position. It is hoped to measure position of the line-of-sight to an accuracy approaching one second of arc.

Studies were conducted to determine the most desirable configuration for improving radar range unit performance at the Arbuckle Neck field site. The proposed new unit would be digital with improved accuracy and increased velocity and acceleration tracking capability. In addition, the new unit would be capable of varying pulse repetition frequency when necessary to eliminate transmitted pulse interference with the return signal. Ambiguities in range measurement resulting from returns outside the pulse repetition period would be resolved.

VI. PRESS PROGRAM

In the KC-135 aircraft, changes to existing as well as new equipment were necessary to prepare the plane for PRESS airborne optics operation, Phase I. Installation and interconnection drawings were modified as required. Design work for Phase II, involving the removal of all existing equipment racks, repackaging and reinstallation of most existing components and addition of inertial guidance and data link equipment, has been started.

Selection of components and design of control and switching circuitry for the 37 servos required in the Phase III installation were continued.

VII. BALLISTIC MISSILE RE-ENTRY STUDIES

Manufacture of the control console for the AMRAD acquisition aid radar was completed. Components necessary for required system operation were added to the SCR-584 pedestal. It is expected that this complete system will be ready for test in January 1963.

Installation of a Clausing machine tool for use in radar cross-section measurements of free-falling models was completed. A new fixture for the machine was designed to handle larger models and to provide an improved release mechanism.

VIII. PROJECT 461

General configuration of a control system for the Project 461 satellite-tracking antenna was determined. Detailed design of servo and switching circuitry was started. Plans call for a mock-up of the main servo systems to be constructed to determine precisely required system parameters before installation of the servos on the antenna mount.